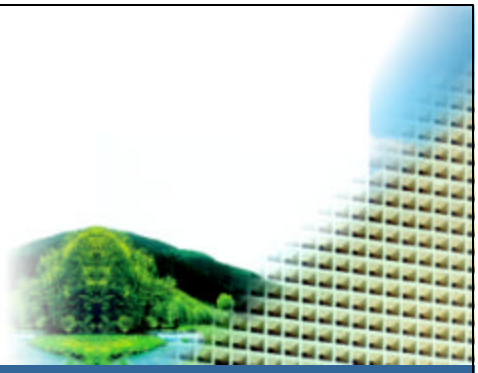

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NOx Reduction for Marine Diesel and Heavy Fuel Oil Engine

Datum 26.07.02

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- Introduction
- Effects on the Environment
- The SINOx SCR System
- SINOx Technology for Marine Applications
- SINOx SCR Figures
- References
- Summary

Problems with Climate and Air Quality influencing

- Greenhouse Effect (global warming) → Climate
- Ozone depletion (UV radiation) → Health, Vegetation
- Smog → Bad smell, Visibility
- Acidification (acid rain) → Aquatic life, Corrosion

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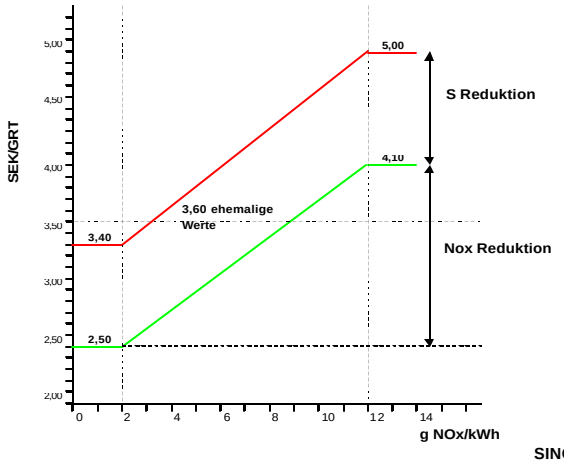
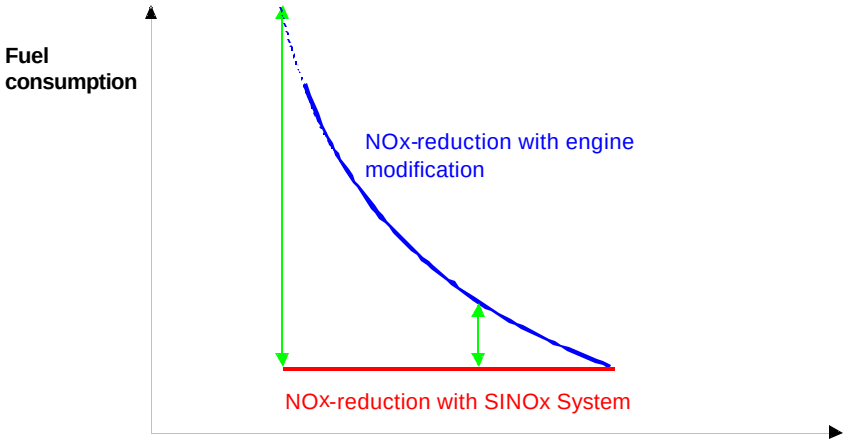
Swedish Maritime Organisation
Environmental Differentiated Fairway Dues



SINOx - Solution of the Diesel Dilemma



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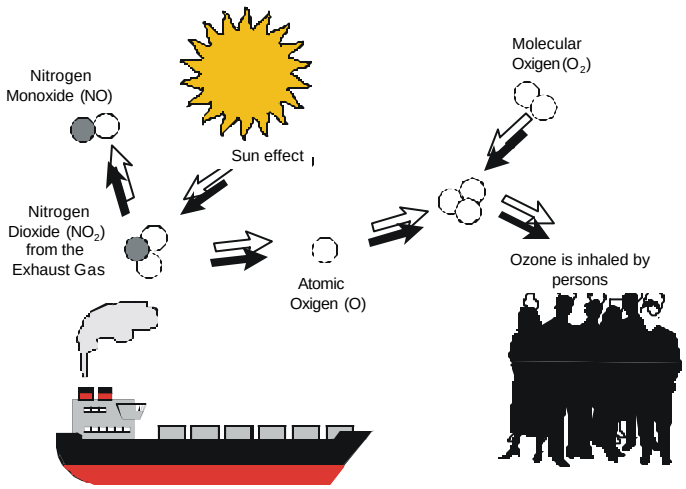
Formation of Ozone (Simplified Version)



Emissions and there Effect on the Environment

Originators	NOx	CO_2	SOx
Greenhouse Effect		X	
Ozone		X	
Acid Rain	X		X
Linked up with			
Fuel Combustion	X	X	X
Incinerators	X		X

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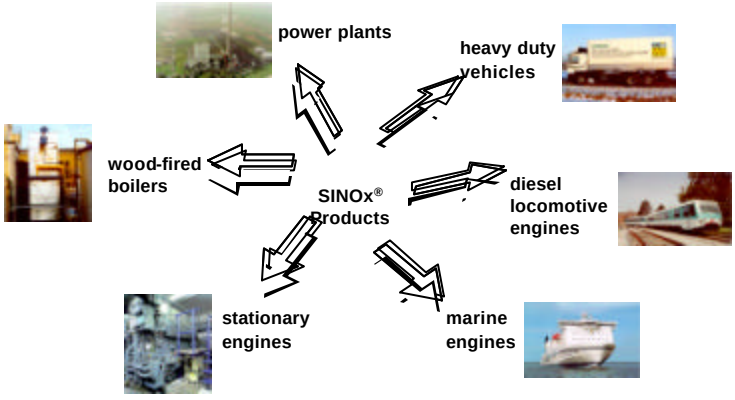
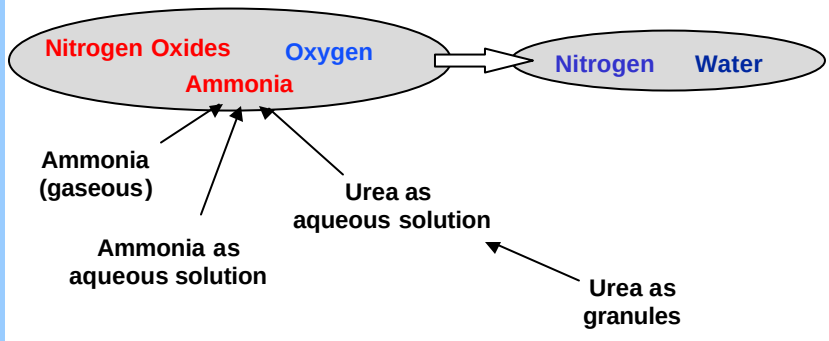
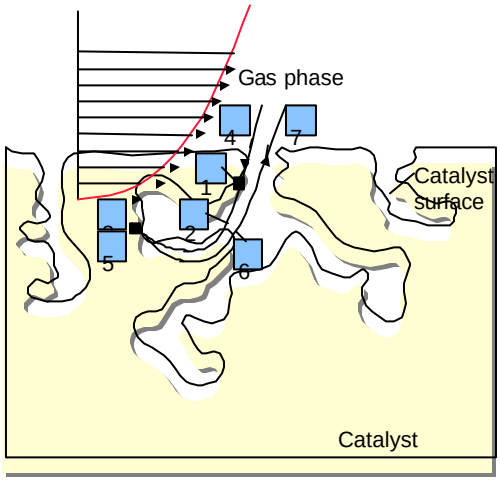
SINOx® - Competence of Applications from Power Plants to Heavy Duty Vehicles



Selective Catalytic Reduction (SCR)

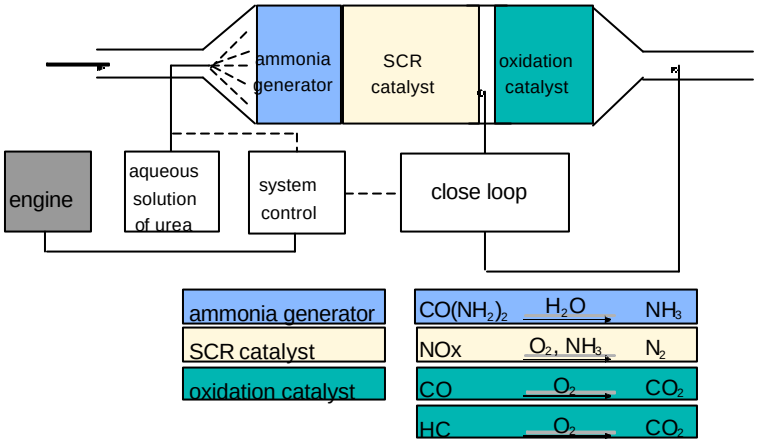
$$4\,NO + 4\,NH_3 + O_2 \xrightarrow{\text{Catalyst}} 4\,N_2 + 6\,H_2O$$





1. External diffusion of NH_3 to catalyst surface
2. Internal diffusion of NH_3 into the catalyst pore
3. NH_3 adsorption on the active centers
4. NO diffusion from gas phase to adsorbed NH_3
5. Reaction of NO and NH_3 to N_2 and H_2O
6. Desorption from N_2 and H_2O from catalyst surface
7. Diffusion of N_2 and H_2O into the gas phase

SINOx Exhaust Gas Cleaning Systems
Principle of the Urea-SCR Technology



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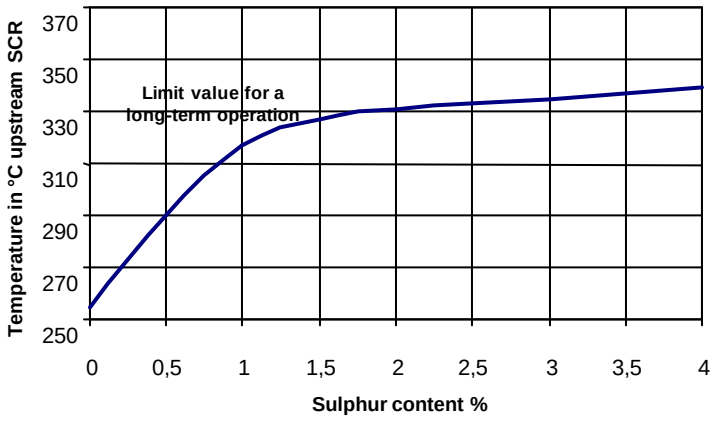

To keep our garantee the following values (maximal concentrations of catalyst poisons in the exhaust gas) must be strictly respected :

Alkali metals	max.	5	mg/m³ wet
Alkali-earth metals	max.	1	mg/m³ wet
Hydrochloric acid, chlorides	max.	100	mg/m³ wet
Hydrofluoric acid, fluorides	max.	1	mg/m³ wet
P_2O_5, organic phosphorus compound, As, As-compounds, Si-organics, Si-halides	max.	0,005	mg/m³ wet
Pb + Zn	max.	0,1	mg/m³ wet
Hg + Cd	max.	0,1	mg/m³ wet

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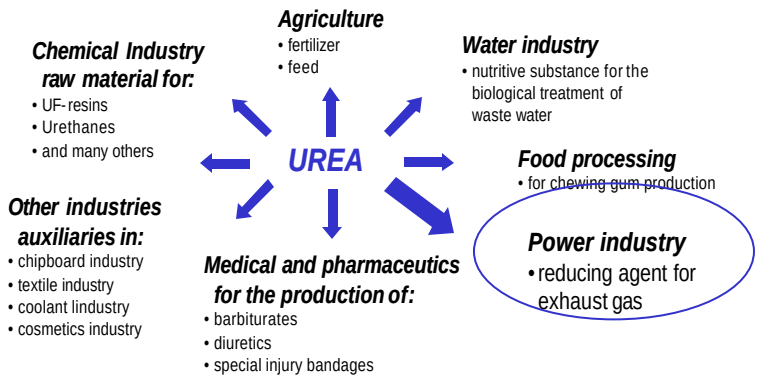
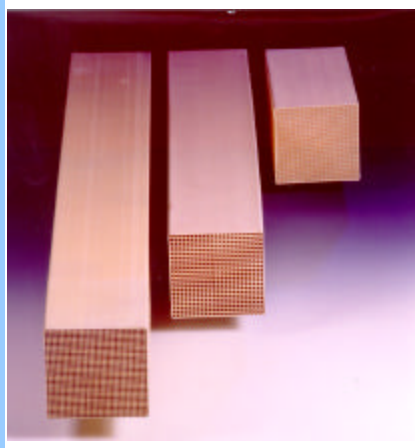
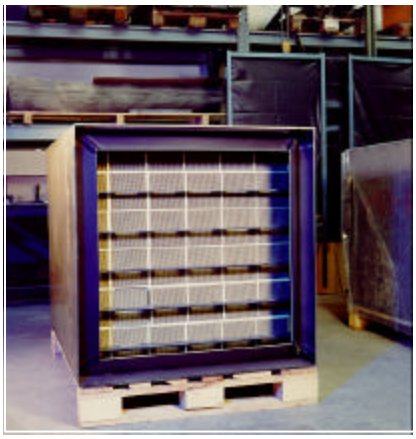
Urea is a commodity product.



SINOx Honeycombs in Module





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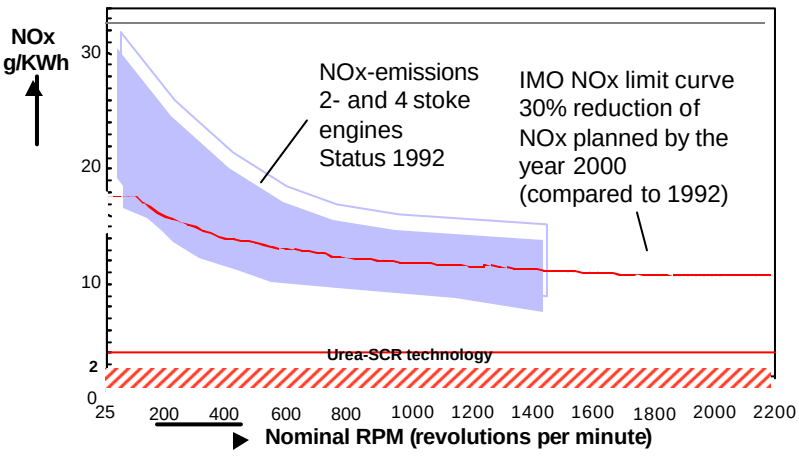
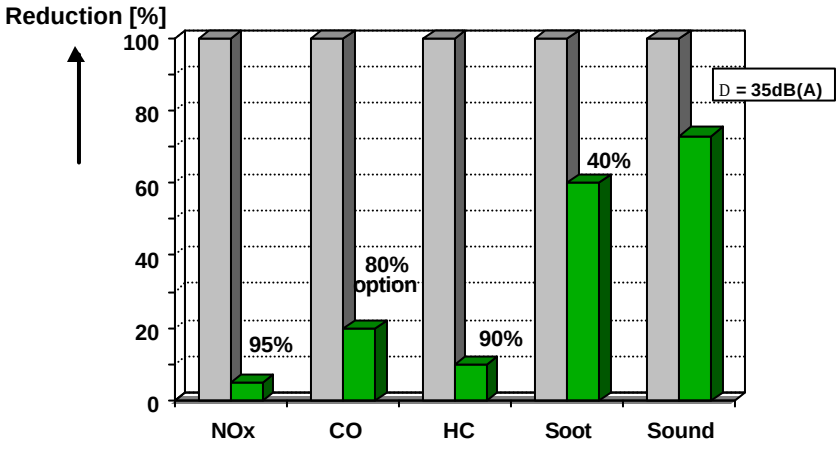
IMO-NOx Emission Limits



SINOx Highlights
Reduction of NOx, CO, HC, Soot and Sound



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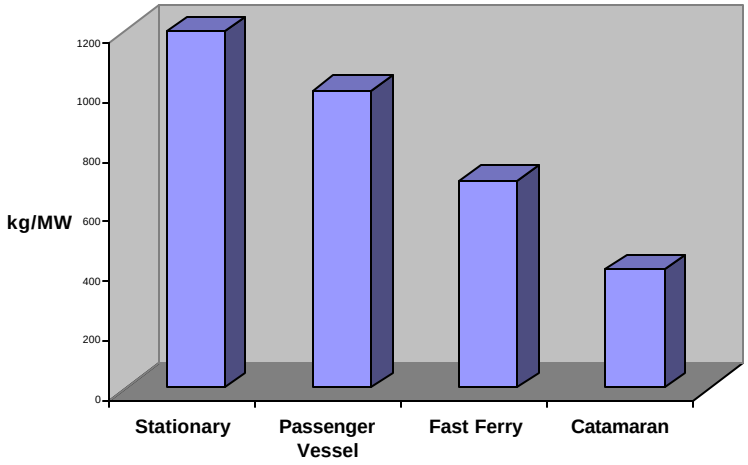
SINOx SCR Figures Marine

Performance	NOx Reduction	90 - 99 % at MCR
	HC/CO Reduction	80 - 90 % at MCR
	Soot Reduction	30 - 40 % at MCR
	Noise Reduction	30 - 35 dB(A)
Operation	Temperature Span	250 - 530 C
	Fuel	MDO/HFO
Installation	Weight	Silencer +30 - 60 %
	Volume	Silencer +/- 20 %
Consumables	Urea Solution (40%)	15 - 20 l/h (per MW)
	Catalyst Life Span	10,000 - 40,000 h
Cost for SINOx	Investment Cost	40 - 70 USD/kW
	Operation Cost	3 - 4 USD/MWh
	NOx Cost	0.35 USD/kg NOx

SINOx Weight Comparison for Different Applications



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Exhaust gas flow:	31,830 lbs/h
temperature:	806°F
NOx -reduction:	< 1.5 g/bhp-hr
urea consumption:	10 gal/h
catalysts:	SW 35
back pressure:	3.0 in W.C.
fuel:	Diesel / MDO

(all given data are typical per line)

urea consumption:	main engines 25 gal/h
	aux. engines 1 gal/h
catalysts:	main engines SW 40
	aux. engines SW 35
back pressure:	main engines 3.8 in W.C.
	aux. engines 2.1 in W.C.
fuel:	Diesel / MDO

exhaust gas flow:	main engines 4x107,430 lbs/h
	aux. engines 3x5,461 lbs/h
temperature:	main engines 878°F
	aux. engines 843°F
NOx -reduction:	< 1.5 g/bhp-hr

(all given data are typical per line)

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exhaust gas flow:	main engines 4x54,380 lbs/h
	aux. Engines 3x3,180 lbs/h
temperature:	main engines 637°F
	aux. engines 748°F
NOx -reduction:	< 1.5 g/bhp-hr

(all given data are typical per line)

urea consumption:	main engines 25.6 gal/h
	aux. engines 1 gal/h
catalysts:	main engines SW 30
	aux. engines SW 30
back pressure:	main engines 2.3 in W.C.
	aux. engines 2.1 in W.C.
fuel:	main engines HFO
	aux. engines MDO

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exhaust gas flow:	main engines 2x67,500 lbs/h aux. engines 3x8,500 lbs/h	urea consumption:	main engines 22.5 gal/h aux. engines 2.1 gal/h
temperature:	main engines 644°F aux. engines 806°F	catalysts:	main engines SW 30 aux. engines SW 30
NOx-reduction:	< 1.5 g/bhp-hr	back pressure:	3.9 in W.C.
		fuel:	main engines HFO aux. engines MDO

(all given data are typical per line)

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exhaust gas flow:	main engines 4x68,800 lbs/h aux. engines 2x37,600 lbs/h
temperature:	main engines 608°F aux. engines 581°F
NOx-reduction:	< 1.5 g/bhp-hr

(all given data are typical per line)

urea consumption:	main engines 239 gal/h aux. engines 14 gal/h
catalysts:	main engines SW 35 aux. engines SW 35
back pressure:	main engines 5.5 in W.C. aux. engines 5.9 in W.C.
fuel:	main engines HFO aux. engines MDO

exhaust gas flow:	main engines 4x24,137 lbs/h	urea consumption:	main engines 7,1 gal/h
	1. aux. engines 2x10,610 lbs/h		1. aux. engines 3,4 gal/h
	2. aux. engines 2x3,713 lbs/h		2. aux. engines 1,1 gal/h
temperature:	main engines 608°F	catalysts:	main engines SW 55
	1. aux. engines 635°F		aux. engines SW 55
	2. aux. engines 878°F	back pressure:	main engines 5,6 in W.C.
NOx -reduction:	< 1.5 g/bhp-hr		aux. engines 5,6 in W.C.
		fuel:	MGO

(all given data are typical per line)

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Summary

- Installation of SINOx represents solution to Diesel Dilemma
- Guarantees to reach the emission limits fixed by environmental authorities - reduced harbour fees
- SINOx's versatility: reduces NOx, hydrocarbons, soot and has a sound attenuation effect
- Installed SINOx systems are able to reduce NOx by approx. 3,5 t/h
- Profitable investment into the future